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THE

AMERICAN NATURALIST.

Vol. VIII.—MAY, 1874.—No. 5.

THE NATURAL HISTORY OF A POLYMORPHIC BUTTERFLY.*

BY SAMUEL H. SCUDDER.

THIS butterfly (*Iphiclides Ajax*) occurs east of the great plains, in the Carolinian and the southern half of the Alleghanian fauna; it extends north almost to the annual isotherm of 50°, even passing that line in the region of the great lakes, so as to include southern Michigan and the whole of Ohio, but, apparently, not following the upward curve of the isotherm beyond the Mississippi. In the south it reaches the gulf coast, but how far it extends down the Florida peninsula is undetermined; its western extension is unknown; it has been reported neither from Texas nor Arkansas, although it is common in Missouri (Riley). Prof. Parker states that it occurs on the Mississippi at least as far north as Rock Island, Ill., and that he has taken a few specimens at Keokuk and Davenport, Iowa, although none at Grinnell. It occurs in southern Michigan (Mus. Mich. Univ., Andrews) and in many localities in Ohio, such as Cleveland—"not uncommon"(Kirtland); "common where papaw bushes are" (Kirkpatrick); Columbus, "still more abundant" than at Cleveland (Kirtland); Rockport, Poland and Hudson (Kirtland) and Eastern Ohio (Foster); a single specimen has been reported from Komoka, Ontario, Canada (Saunders). In

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* This article is an extract from the chapter upon *Papilio Ajax* in Mr. Scudder's forthcoming work upon the Butterflies of New England and the adjoining regions; this will account for the form in which it is here presented.—EDS. NAT.

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Maryland (Uhler) it is "rare" and about Philadelphia (Blake) it is not common. Finally, one specimen has been taken near Brooklyn, N. Y. (Graef *fide* Akhurst).

As in some other dimorphic species, however, the distribution of the several varieties does not seem to be coextensive with that of the species. Unfortunately, our information here is very meagre, since the polymorphism of the insect has only recently been proved. It is, however, certain that the numerical superiority of the variety Marcellus over Walshii and Telamonides is far greater in the north than in the south; indeed, near the northern limit of the insect's range, Walshii and Telamonides are hardly known, and in extreme northern localities where only a few specimens have been recorded, these have always been Marcellus.

The caterpillar, according to numerous authorities, feeds upon the papaw (*Asimina triloba* Dunal) and, according to Dr. Chapman, upon other species of the same genus such as *A. parviflora* Dunal, *A. grandiflora* Dunal, and *A. pygmæa* Dunal. Boisduval and Le Conte also state that it feeds upon the latter and upon *A. palustris*,—plants belonging to the Anonaceæ or custard-apple family.

Some of the caterpillars, as shown by Mr. Edwards' observations, attain their full growth in twelve days, although others, especially the produce of the form Walshii, require nearly a month. They do not draw the leaves of the plant together like the larvæ of the genera represented by Troilus and Glaucus. They are to be found in every stage "resting on the surfaces of the leaves, and one would suppose they must be nearly exterminated by birds. But like all Papilio larvæ they emit from the head [first thoracic segment], at the same time that they project a Y-shaped tentacle, a peculiarly acrid and sickening odor, which must effectually protect them."* In a letter, Mr. Edwards adds that he does "not believe a starving bird would touch one, the stench being so strong as nearly to turn one's stomach."

Science is deeply indebted to Mr. Edwards, for the thorough manner in which he has worked out the history of this butterfly by careful studies in the field and innumerable experiments. This author has not only indisputably established the identity of two forms previously described as distinct species (though often presumed to be identical), but has proved the existence of a third permanent form and has admirably traced the relations of each form to the others. The account given below is almost entirely based on his observations.

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* Edwards, Butterflies N. America, part ix.

No histories of butterflies are of deeper interest than those of polymorphic species, whether considered in themselves alone or in the light they are destined to throw upon the origin of species and races, problems which demand the profoundest thought and most conscientious investigation; and since this species is polymorphic in a larger sense than any other American butterfly is known to be, our interest is greatly enhanced.

As hinted above, Ajax appears under three different forms — Walshii, Telamonides and Marcellus, the polymorphism affecting both sexes equally. These forms are shown by Mr. Edwards to produce one another in a complicated manner, but in general the imago exhibits what has been termed seasonal polymorphism; that is, a series of individuals adhering, in all their variations, to several distinct types, each type appearing at a different season of the year from the others; thus Walshii is the early spring type, Telamonides the late spring, and Marcellus the summer and autumn type. Nearly all the butterflies which, in West Virginia, emerge from the chrysalis before the middle of April are Walshii; between that and the end of May, Telamonides; after this, Marcellus. The first two, however, do not appear properly to represent distinct *broods;* and this point (to which Mr. Edwards has failed to draw special attention) is one of the most extraordinary features in the history of the insect; for Telamonides, judging from his recorded observations, is not the direct conseasonal produce of Walshii, but both are solely made up of butterflies which have wintered as chrysalides, those which disclose their inmates earliest producing Walshii, the others, Telamonides; while all butterflies produced from eggs of the same season — and there are several successive broods — belong to Marcellus. Thus, besides the true seasonal dimorphism which distinguishes the butterflies produced from eggs of the same season from those derived from eggs of the previous season, we have a secondary seasonal dimorphism, as it may well be called, separating the earlier from the later produce of wintering chrysalides.

Mr. Edwards has also proved by his experiments that a portion of every brood of chrysalides, instead of disclosing the imago at the end of the ordinary time, retain it, occasionally until the appearance of a subsequent brood, but usually until the next spring. The spring brood (Walshii-Telamonides) is therefore by no means wholly produced from chrysalides of the final brood of Marcellus, but in large measure from those of all the earlier broods, even including the earliest Walshii; the proportion of chrysalides which continue until spring increases as the season advances, Mr. Edwards' statements showing that of those produced from eggs laid in April, more than ten per cent. pass over, those from eggs laid May 1-25 about thirty-five per cent., from that time until the end of June from fifty to sixty per cent. and from those laid in July about seventy per cent. Walshii and Telamonides, then, produce Marcellus the same season, or either Walshii or Telamonides in the spring; Marcellus produces itself the same season, or one of the others in the spring; but neither Walshii nor Telamonides is produced the same season by any of the varieties.*

We will now consider the life-history of Ajax. The insect is multibrooded and winters as a chrysalis. The earliest variety, Walshii, "appears in the Kanawha valley (W. Va.), from the 15th to 20th of March, by which time the peach trees are usually in blossom. On these the females may certainly be found, and a little later, on the apple and in great numbers on the wild plum. The males appear a few days earlier [than the females] and are to be seen by the water-side or upon the road, but rarely upon flowers. The larvæ feed on the papaw, and as this is one of the latest of our trees to put forth its leaves, the butterflies are out at least from two to three weeks, before the young shoots of the food plant are visible. But no sooner do these appear than the females hasten to deposit their eggs."† This is early in April and they continue to lay them until as late as May 23d; the eggs hatch in from seven to eight days and the caterpillars are from twenty-two to twenty-nine days in attaining their growth.

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* The recorded exceptions to this rule (which serve only to strengthen it) are the following: a Telamonides was captured September 12th, and a Marcellus April 11th; the other exceptions occurred in the course of Mr. Edwards' experiments. This indefatigable worker has traced the history of more than two hundred individuals from egg to butterfly, and of these only two did not follow the usual course; these two belonged to a brood produced from eggs laid by Walshii before the middle of April; sixty individuals completed their transformations the same year; all (excepting a pair of belated Marcellus) hatched between June 1st and 6th; fifty-eight chrysalides produced Marcellus, one Walshii and one Telamonides; so that the solitary specimen of Walshii was far out of season, for Mr. Edwards expressly says: "about the first of June Walshii *disappears*" while the one specimen of Telamonides was certainly much later than usual; and in any case, Walshii should produce neither Walshii nor Telamonides the same season. It must be remembered that similar instances of untimely eclosion are by no means very uncommon among butterflies.

† Edwards, Butterflies of N. America. Unless otherwise stated, all these remarks are based upon Mr. Edwards' observations in W. Virginia.

Telamonides, which, as stated above, is only a later variety of the same brood, "begins to fly some weeks after Walshii, and both forms . . . . are for a time common." Telamonides evidently lays its eggs very soon, for "on dissecting the abdomen of a newly emerged female, the eggs are found to be fully formed though not full-sized. I conclude that they mature with great rapidity because fertile eggs are laid by apparently fresh and uninjured females." Mr. Edwards records eggs laid from May 11th to June 2d; these are hatched much more rapidly than those of Walshii (although they are not always laid later in the season), namely, in from four to five days; the caterpillars, too, mature more quickly, attaining their growth in from fifteen to eighteen days, thus often overtaking their tardier predecessors. "About the first of June Walshii [imago] disappears, and before the end of the month Telamonides also."

Still farther south, it is evident that the apparition of the butterflies is advanced; for in Georgia, Abbot records Walshii as emerging from the chrysalis March 2d, and Dr. Chapman took it in northern Florida, in the latter half of February, 1868 and 1869; late in March he also records the species as "numerous," so we may perhaps fairly surmise that Telamonides appears at this time.

"About the first of June, Marcellus begins to appear and shortly is out in great numbers, continuing to be abundant till last of October." The broods overlap each other so as to be distinguished with difficulty, but it appears that, besides the brood of Walshii-Telamonides already mentioned, there are at least three successive broods of Marcellus.* The larvæ of Telamonides, as we have seen, often overtake the later larvæ of Walshii—the earlier larvæ are by this time (the middle of May) in chrysalis and continue fourteen days; the first brood of Marcellus from these chrysalides, and from those of Telamonides, continues to emerge until at least the ninth of July, or for more than five weeks.† The chrysalides from larvæ of Telamonides hang from eleven to fourteen days, and the time for the completion of their entire cycle is only from thirty to thirty-seven days, which is seldom exceeded by Marcellus (twenty-seven to thirty-eight days), although much quicker than the period of Walshii (forty-three to fifty-one days).

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* Mr. Edwards' language on this point seems a little vague; he says: "Besides the first brood from Walshii, or Telamonides, there are three successive broods of Marcellus, and the larvæ of the fourth give chrysalides that go over the winter, thus making five broods per year."

† Speaking of a brood of larvæ from eggs of Walshii, reared in 1871, Mr. Edwards says that while the mass of the chrysalides (all of which suspended within a week of

The female of the first brood of Marcellus commences to lay eggs — which, like those of Telamonides, hatch in four or five days — at the very beginning of June, and butterflies produced from them, *i. e.* the second brood of Marcellus, are upon the wing early in July — not only before the butterflies of the previous brood have disappeared, but even before all the chrysalides from eggs of Telamonides have eclosed their butterflies; the attempt to trace the sequence of the broods is, therefore, almost hopelessly bewildering; but it seems probable that the second brood of Marcellus (the third of Ajax) appears in abundance early in July; it is, perhaps, in speaking of the first brood of Marcellus in Alabama, that Gosse says they are "nearly all gone July 1st." These larvæ attain their growth in from twelve to nineteen days, and hang as chrysalides from eleven to fourteen, and it is therefore impossible that there should not be a third brood of Marcellus; that a fourth brood is even at times possible would appear from the fact that the insects continue to change from one stage to another without any apparent regard to the approach of winter, which overtakes many in conditions under which they are obliged to succumb; thus Mr. Riley writes from Missouri: "I have found eggs and larvæ two-thirds grown, as late as the middle of October, when the leaves were almost all fallen; the parent ought to know better if instinct is so infallible." Doubleday remarks that on the Ohio the species was very numerous after the tenth of September; if this is an indication of a new brood in September, and if the second brood of Marcellus appear early in July in this locality also, then the butterflies seen by Doubleday must have been a fourth brood of Marcellus, or the fifth of Ajax. I do not think there is another instance on record of a five-brooded butterfly.

The results reached by Mr. Edwards in his study of this butterfly have recently been the subject of some curious comments by

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each other) eclosed the butterflies between June 1st and 6th, yet "on 23d June, full three weeks after its period, came another ♀ Marcellus and a second followed on the 12th of July;" but even the latter date is only three days after that of others of this brood (from eggs of Telamonides however), which were but thirty-seven days from egg to butterfly.

Mr. Meldola of England, in a paper upon the "amount of substance waste undergone by insects in the pupal state."*

This writer thinks he has shown that the comparative size of the three forms of Ajax is exactly opposite to what we should expect. In his preliminary general remarks, it is presumed *a priori* that as there is in all insects gain of matter in the larval state, and loss during the pupal, the size of an individual of any given species "would be, *cœteris paribus*, inversely proportional to the ratio of the pupal to the larval period, or directly proportional to the ratio of the larval to the pupal period."

He attempts to test this theory by tabulating the statements of Mr. Edwards concerning the duration of the stages in the different forms of Ajax, and he finds that there is "a relationship but exactly the reverse of that which would be anticipated from the conclusions previously set forth."

Walshii, Telamonides and Marcellus, as we have seen, succeed each other in season; they also increase regularly in size in the same order. The following table represents the duration of the several stages and is taken by Mr. Meldola from Mr. Edwards' work.

NAME OF VARIETY.	EGG.	LARVA.	CHRYSALIS.	TOTAL.
Walshii . . .	7–8 days	22–29 days	14 days	43–51 days
Telamonides	4–5 "	15–18 "	11–14 "	30–37 "
Marcellus . .	4–5 "	12–19 "	11–14 "	27–38 "

The next table is Mr. Meldola's attempted tabulation of the facts, by which he comes to the above conclusion.

NAME OF VARIETY.	RATIO OF MEAN PUPAL TO MEAN LARVAL PERIOD.	RATIO OF MEAN LARVAL TO MEAN PUPAL PERIOD.	MEAN EXPANSE ♂.
Walshii	$\frac{14}{25\cdot5} = 0{\cdot}549$	$\frac{25\cdot5}{14} = 1{\cdot}821$	2·70
Telamonides .	$\frac{12\cdot5}{16\cdot5} = 0{\cdot}757$	$\frac{16\cdot5}{12\cdot5} = 1{\cdot}320$	3·00
Marcellus . . .	$\frac{12\cdot5}{15\cdot5} = 0{\cdot}806$	$\frac{15\cdot5}{12\cdot5} = 1{\cdot}240$	3·35

"It is here seen," says Mr. Meldola, "that the size of the variety is directly instead of inversely proportional to the ratio of the pupal to the larval period, and *vice versâ*." Unfortunately for this conclusion the figures given by Mr. Edwards, or their reduction by Mr. Meldola, refer in each case to the *progeny* of Walshii, Telamonides and Marcellus, and do not bear upon the question at all. In every instance given in the tables, the progeny or resultant is Marcellus. By Mr. Meldola's rule, Walshii and Telamonides, being the produce of wintering chrysalides, should be, as they are, smaller than Marcellus, since the latter is always the result of short-lived, summering chrysalides; unless, however, some unknown factor plays a part, Telamonides should be smaller than Walshii, because produced later in the season from wintering chrysalides; but here the opposite is the case.

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* Ann. Mag. Nat. Hist., Oct., 1873, p. 301.

The extreme abundance of Ajax is well attested by Edwards, when he says: "at certain seasons it is almost impossible to find a young plant [of papaw] that is free from . . . . eggs and it is easy to collect scores of them."

"The female of Ajax may frequently be seen coursing through the papaw trees which . . . . . cover the lower hillsides, or hovering about the young plants that spring up in the cultivated fields, searching for leaves on which to deposit her eggs. After touching or running over and rejecting several, she finds one suitable to her purpose. Thereupon balancing by the rapid fluttering of her wings, she stands for an instant with legs stretched at full length, perpendicular to the body, and curving down the abdomen until it touches the surface, deposits a single egg; then flies away, presently to alight on a second leaf with like intent. Sometimes the egg is upon the stem, and occasionally on the under side of the leaf, but almost always it is upon the upper side, and but one egg will usually be found on the same leaf. The process of laying continues for several successive days." (Edwards).

Doubleday, speaking in particular of the spring-brood writes:* "I rarely saw it alight on flowers. Now and then it would alight on flowers of *Anona grandiflora* . . . . . its flight low, rapid (not sailing with its wings expanded as *P. Thoas* and others). It flies in and around the low scattered brush wood, by the sides of clearings, old deserted cotton fields, and similar situations, often returning to the same spots; in fact so regular did the round seem to be taken, that I have often waited behind a bush for a few minutes for the return of an individual I had seen pass, and rarely failed by this means to capture it. It is a shy insect and darts out of its course at the least motion." Speaking of the autumn brood, which he considers a distinct species, he adds (*loc. cit.*): "its flight is rather more graceful than that of *P. Ajax* [*i. e.* the spring brood]; it sometimes alights in the muddy places by the roadsides where little streamlets cross, especially during the heat of the day." Kirtland, too, remarks: "these two species are readily recognized by their peculiar mode of flight;"* but Edwards makes no comment upon this point.

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* Arcana Entomologica, i, 61.

"Many eggs," says Edwards, "are destroyed by insects and spiders. There is a minute scarlet spider scarcely larger than the egg itself, that mounts upon it and from a puncture extracts the contents. I frequently met the shells so despoiled before I discovered the cause, and have since observed the marauder in its operations. I have also lost in a single night, owing as I supposed to crickets, numbers of eggs laid in confinement." Speaking of the caterpillar he says: "I have . . . seen spiders feeding upon them, attacking even the head, and they have other enemies among the insects. They are very little troubled by ichneumon flies in this valley, and I have rarely lost a chrysalis from that cause. Consequently no Papilio is so abundant here throughout the season. I find on breeding them that a considerable percentage of the eggs do not hatch, and that more or less of the larvæ die at every moult, as well as in the effort to change to chrysalides. Multitudes of chrysalides must be destroyed in the winter by birds and mice as they are but imperfectly concealed under stones and roots, or even among the stems of the grasses, so that of the tens of thousands of eggs that are annually deposited, but a very small proportion produce butterflies." The caterpillar is, however, sometimes attacked by *Trogus exesorius* Brullé, the imago of which escapes from the chrysalis by cutting a circular opening, usually through one of the wings.

Desiderata. Although so carefully studied by Mr. Edwards, there are still some points in the history of Ajax which require investigation. The distribution of the insect in the west and of each form throughout its natural range should be more definitely determined. The season of the apparition of the different varieties in the extreme southern states, and of the different broods of Marcellus everywhere, is still unknown and will require careful study;

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* Trans. Entom. Soc. Lond., n. s. i, 1851, Proc. ci.

but perhaps the most interesting and fruitful investigation will be to follow still further the line of Mr. Edwards' experiments, and study the proportion of chrysalides of each brood which retain their inmates until spring; noting every instance of the partial retention of the chrysalis, to discover to what extent pupæ, apparently destined to hibernate, disclose the butterfly the same season; and, further, to determine whether both Walshii and Telamonides are indifferently produced from any of the broods of the previous year. Mr. Meldola's studies would lead us to conjecture that Walshii is generally produced from the later broods of Marcellus, and Telamonides from the earlier broods of the same, and from Telamonides and Walshii; but Mr. Edwards' experiments show that this is not invariably the case. The postures of the butterfly have not been described.

THE GAME FALCONS OF NEW ENGLAND.
THE SPARROW HAWK.

BY DR. WILLIAM WOOD.

This beautiful little hawk has the peculiar markings of the true falcon, and is the smallest and handsomest of the family Falconidæ. It is found all over the continent, and is said to be the most numerous of the hawk family. While this no doubt is the fact, yet in New England it is not common. It is about as rare as the pigeon hawk, but not so irregular in its visitations. I have received only ten specimens in twenty years. Allen in his ornithological notes on the birds of the Great Salt Lake Valley says, "The sparrow hawk was by far the most numerous of the Falconidæ. Thirty were seen in the air at one time near the mouth of Weber Cañon engaged in the capture of the 'hateful' grasshopper, which everywhere filled the air and which seemed at this season to form the principal food of this and other birds." In the southern states where it is very numerous it may be seen about the old fields, orchards and gardens, sitting erect on a fence, stake, mullein stalk, or a dead limb of a tree, watching for small birds, mice, grasshoppers or beetles, upon which it chiefly subsists, seldom